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Aalto-1 Earth Observation nanosatellite mission status and in orbit experiments

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1. Introduction

In this paper we will describe a Finnish Aalto-1 CubeSat satellite and describe the first in orbit results of the Earth Observation mission. The Aalto-1 is built by a consortium of universities and institutes and also with a close link to the industry. The mission has goals in education [1], technology demonstration and science. The mission brings Finland also to the widening circle of space faring nations as it is expected to be the first Finnish satellite launched. The original mission idea was developed by Aalto University students in 2010 and the satellite was designed and built as an university project together with wide academic and industrial consortium. The satellite platform was developed by university while the payloads were developed by various consortium partners. The main payload of the mission is a miniature hyperspectral camera AaSI. In this paper we give an overall description of the satellite and its hyperspectral Earth Observation (EO) payload with an emphasis on first in orbit results for EO mission.

2. Aalto-1 satellite overview

The Aalto-1 satellite is a 3U CubeSat standard satellite. Mass of the satellite is 4 kg and it carries three different payloads, each designed specifically for this satellite. The payloads are provided by project consortium partners as follows: VTT Technical Research Centre of Finland, Finnish Meteorological Institute, University of Turku and University of Helsinki. Each of the payload has its own mission goals and each payloads sets certain requirements to the platform. Therefore, the satellite has rather complex design and mission. The satellite features a 3-axis attitude stabilization, two channel radio link and fully redundant TT&C radio and On Board Computer architecture. The mission of the satellite is mainly technology demonstration related to the payloads and the satellite platform. [2, 3]

3. Earth Observation payload and mission

The main payload of the satellite, shown in Figure 1, is a miniature spectral imager AaSI (Aalto-1 Spectral Imager) which is designed for Earth Observation by VTT Technical Research Centre of Finland. The instrument is based on a Piezo-actuated tunable Fabry-Perot interferometer and it is able to record 2D spatial images at one to three wavelengths simultaneously. In few seconds it is able to gather tens of freely programmable spectral channels and form a spectral cube of the target. Simultaneous multiple channel data collection is enabled by matching the transmission function with the sensitivities of the CMOS (complementary metal-oxide semiconductor) colour image sensor. The spectral camera is accompanied with secondary VIS camera for collecting reference images with wider swath. The spectral camera has a field of view of 10 degrees and the nominal image size is 512 pixels x 512 pixels. The imager can be programmed to measure 10 nm - 20 nm spectral channels in the spectral range of 500 nm - 900 nm. The payload consumes power from 1 W - 2.5 W, depending on the operation mode. The ground resolution of the image is expected to be less than100 m. The instrument is based on an earlier instrument developed at VTT for UAV platforms and it is one of the smallest spectral imagers currently available for CubeSat. The dimensions of the modular instrument are 97 mm x 95 mm 48.3 mm and mass 592 g. The AaSI instrument can be integrated to a common CubeSat Kit type electronics stack. [4, 5]

The main mission of the imager is to demonstrate Fabry-Perot interferometer based optical imager for Earth Observation applications. The miniature AaSI instrument is able to provide image resolution comparable with MODIS instrument, while it is significantly smaller. The campaign goals are set to image various natural targets, such as sea, land and forest. Several remote sensing image use-cases are demonstrated, such as land use classification, vegetation mapping and algae detection. [6, 7]

3. Secondary payloads and secondary mission

The secondary payload is a radiation monitor RADMON, which detects the particle energy loss (ΔE) in the thin detector and the residual energy (E') in the scintillator for all incident particles. The two signals enable the identification (electron or ion) and the determination of total energy of the particle. The data product consists of (>10 MeV) proton and (>700 keV) electron fluxes in several energy pass bands at 15-second time resolution. The payload is developed by the University of Turku and the University of Helsinki. The RADMON will carry out its observations during the first 6 - 12 months of the mission. It will combine the information of the flux with information on time and location to map the flux of energetic particles at LEO and its temporal evolution. [7]

The third payload is an experimental de-orbiting device, called Plasma Brake. The decice is developed and constructed by Finnish Meteorological Institute. The Coulomb drag tether experiment attempts to open a 100 m long spin-stabilised very thin metallic tether, bias it to high voltage ±1 kV and measure the resulting Coulomb drag [5]. The Coulomb drag results from electrostatic interaction between the charged tether and the ionospheric plasma ram flow incident on the tether. In LEO, negative polarity Coulomb drag is usable for satellite deorbiting [7, 8]. After deploying the tether, the Coulomb drag is measured primarily by turning on and off the tether voltage in a synchronous way with the rotation so that, for example, the voltage is on when the tether moves downwind with respect to the plasma ram flow and off when it moves upwind. In this case, the tether's and the satellite's spin increases in each spin period, and the effect accumulates over each spin and yields a large, easily detectable change in the spin rate after a few hours or less. A second, independent way to measure the effect is to look at changes in the satellite orbit. The final goal is to deorbit the satellite whether possible. [8, 9, 10]

4. Launch preparations and schedule

In 2015, Aalto University agreed with Innovative Solutions in Space company about the launch of Aalto-1 satellite on board of Falcon 9 rocket, in the framework of SHERPA launch. The launch schedule experienced significant delays due to a launcher failure in July 2015 and September 2016. The Flight model is integrated to the deployer in May 2016. The Aalto-1 satellite is a part of ISILAUNCH 09, which is respectively part of a larger SHERPA launch with Falcon 9. Orbit of the satellite will be a slightly elliptical Sun synchronous morning orbit with apogee approximately at 720 km and perigee at 460 km. According to the current schedule, the satellite is due to launch in second quarter of year 2017.

5. First in-orbit results

The satellite should be launched by the beginning of the conference. All the first results will be covered in the conference.

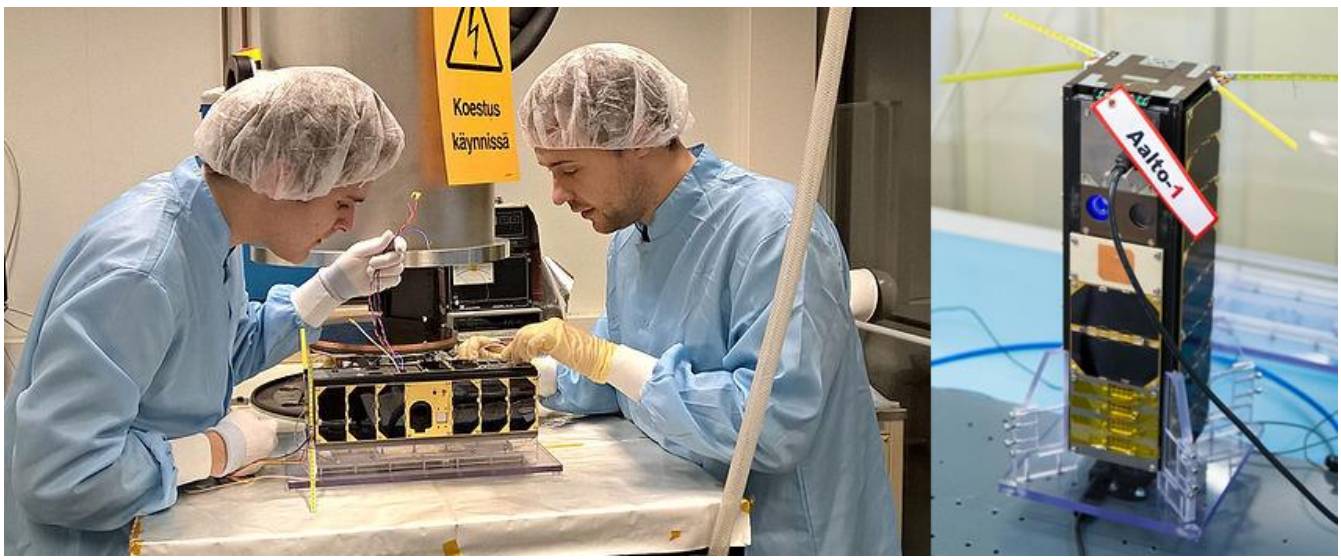

Figure 1. Aalto-1 quality manager Tuomas Tikka and and systems engineer Antti Kestilä preparing the Aalto-1 satellite for thermal-vacuum test. The satellite Flight Model on the right.

4. References

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